# THE 2.5-5.0 μM SPECTRA OF IO: EVIDENCE FOR $H_2S$ AND $H_2O$ FROZEN IN $SO_2$

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The techniques of low temperature spectroscopy are applied here to identify the constituents of the ices covering the surface of Io, a satellite of Jupiter.

Infrared spectra of Io in the 4000-2000 $cm^{-1}$ region, including new observational data, are analyzed using laboratory studies of plausible surface ices.

Besides the well-known absorption bands attributable to sulfur dioxide frosts, four unidentified infrared spectral features of Io are pointed out. Two are at 2597 $cm^{-1}$ and 2558 $cm^{-1}$ and the second pair fall at 3367 $cm^{-1}$ and 3175 $cm^{-1}$. These absorptions fall close to the fundamental X-H stretching modes in $H_2S$ and $H_2O$ respectively. The infrared absorption spectra of mixed molecular ices ranging from pure materials, to binary mixtures of $H_2S$ and $SO_2$ (either mixed at different concentrations or layered), to $H_2O/H_2S/SO_2$ mixtures are discussed. The effects of ultraviolet irradiation (120 and 160 nm) and temperature variation (from 9 K to 130 K) on the infrared spectra of the ices are also examined. The comparative study shows that: (1) Io most likely contains $H_2S$ and $H_2O$ mixed with $SO_2$. The 2597 $cm^{-1}$ and 2558 $cm^{-1}$ bands in the Io spectra can be accounted for by the absorption of the S-H stretching vibration ($\nu_1$) in $H_2S$ aggregates and isolated molecules in an $SO_2$ matrix. The weak 3367 $cm^{-1}$ and 3175 $cm^{-1}$ bands which vary spatially and temporally in the Io spectra coincide with the $\nu_3$ and $\nu_1$ O-H stretching vibrations of clusters of $H_2O$ complexed with $SO_2$. (2) The observations are well matched by $SO_2$.matrices containing about 3% $H_2S$ and 0.1% $H_2O$ and which have been formed by the condensation of a mixture of the gases onto a 100 K surface. (3) In the comparison of the spectra using the mixed molecular ice samples versus the layered ice samples only the former can explain the shifts and splitting of the absorption bands in the Io spectrum and account for the fact that solid $H_2S$ is observed in the surface material of Io at temperatures and pressures above the sublimation point of pure $H_2S$. In addition to pointing out the presence of $H_2S$ and $H_2O$ on Io, the originality of this study comes from the fact that it is the first to consider mixed solids in carrying out laboratory simulations of planetary surfaces providing a realistic simulation of the "dirty" ices covering the surfaces of many satellites.



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